

Construction of the Multi-sensory Service Space to increase the Neuro-energy

Jung-Min Kim

*Department of Building Equipment & System Engineering,
Gachon University, 1342 Seongnamdearo, Sujeong-gu,
Seongnam-si, Gyeonggi-do, South Korea
E-mail: kjm7393@gachon.ac.kr*

Myung-Ho Kim

*Department of Building Equipment & System Engineering,
Gachon University, 1342 Seongnamdearo, Sujeong-gu,
Seongnam-si, Gyeonggi-do, South Korea
E-mail: ibs@gachon.ac.kr*

Abstract

In this study, amenity, concentration, and change in the physical & psychological stability were analysed by measuring EEG, learning ability, HRV and fluctuation image in the multi-sensory stimulation, using sound source of fluctuation $a=1.106$, lighting of RED(0.6975, 0.3021) and jasmine scent in air-conditioned room under the same condition of the temperature of 25[°C], 50[RH%] of relative humidity, 1,000[lux] of illumination and 0.02[m/sec] of air flow velocity. This research revealed that emotional and psychological stability and concentration were the highest, while stress and fatigue decreased more than ever, and heart remained stably sound in the multi-sensory stimulation of jasmine scent and the sound source of fluctuation $a=1.106$. In addition, when exposed to multi-sensory stimulation, neuro-energy increased by 22.26% in the average compared to otherwise. Accordingly, in terms of the act to use energy rationally, when room temperature must be kept at 28°C during summer, at 18°C during winter the design of multi-sensory stimulation is expected to reduce new renewable energy and fossil fuel energy and improve neuro-energy.

Keywords: Neuro-energy, Multi-sensory stimulation, EEG, HRV, Vibra image

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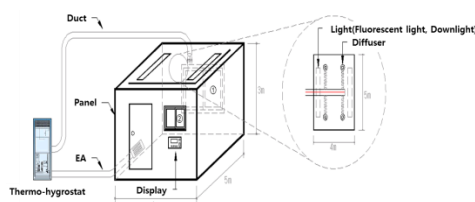
1 Introduction

Energy includes the new renewable energy, the fossil fuel energy, the physical energy with the use of muscles, and the neuro-energy, which shows psychological energy with the use of perception and sense.[1] The indoor environmental factors adjust physiological rhythm by changing Circadian system in the body, sensitivity and intelligence, thereby changing an occupant's neuro-energy.[2] Grasping the influence of indoor environmental factor upon human body in this way has important significance in improving neuro-energy.[3] However, it is difficult to find the research results on multi-sensory stimulation according to the combination of single-sensory stimulation in the indoor environmental factors. Hence, this study conducted multi-sensory stimulation by applying sound fluctuation $a=1.106$ sound, RED lighting and Jasmine scent in the steady temperature and humidity room with the same conditions in temperature $25[^\circ\text{C}]$, relative humidity $50[\text{RH}\%]$, illuminance $1,000[\text{lux}]$ and air velocity $0.02[\text{m}/\text{sec}]$, which satisfy the comfort zone, by ASHRAE(American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.).[4]

2 Method

2.1 Condition of the environmental test room

The inside image of air-conditioned room in this study is shown in figure 1. Data in the steady temperature and humidity room include temperature $-10\sim 40[^\circ\text{C}]$ (error range $\pm 0.5[^\circ\text{C}]$), humidity $20\sim 90[\text{RH}\%]$ (error range $\pm 3[\text{RH}\%]$) and illuminance $0\sim 2,000[\text{Lux}]$ (error range $\pm 3[\text{Lux}]$).



(a) Schematic Diagram



(b) Interior Photograph

Figure 1 Structure fo Environmental Test Room

2.2 Condition selection of sense stimulus

2.2.1 Auditory stimulus due to the sound fluctuation a index

The frequency unique to sound source is referred to as fluctuation, where energy spectrum is inversely proportional to f frequency.[5] With the value of index a being decline, the range of $0.5 \leq a \leq 1.5$ is said to be fluctuation, and as the value of index a becomes close to "1", it induces mental stability.[6] Fluctuation was measured by using the sound source of Jazz Bellavia which induces reduction of stress and relaxation.[7]

2.2.2 Visual stimulus due to the color temperature

RED lighting, low color temperature of 2000~ 3000[K] like the glow of setting sun which induces psychological stability and relaxation was used.[8] Chromaticity coordinate was measured by using CL-200A(KONICA MINOLTA Inc.), a device to measure color temperature of lighting, chromaticity coordinate.

2.2.3 Olfactory stimulus due to the aroma

Jasmine scent was used as olfactory stimulus since it is effective to reduce stress and depression by inducing clear mental state through activating beta wave of brain.[9]

2.3 Measurement and analysis of physiologic signal

The subjects in this experiment were selected 15 university students at the ages of 25~28. The subjects' activity level was set to be 1met (metabolic rate: 1met=58.2 W/m²) as the active mass when taking rest by being seated on a chair in the comfortable thermal condition. The clothing-weight state was unified with about 0.7clo (socks 0.10, pants 0.05, half sleeves 0.25, shorts 0.28).[10]

The measurement of brain wave was utilized PolyG-I (Laxtha Inc.), which is the specialized bio-signal measuring equipment. To analyze quantitative brain wave, the measurement was made for 5 minutes per 1 time based on the analytical unit. Stress and HRV (Heart Rate Variability, HRV) were gauged by applying SA-6000(Medicore Co. Ltd., Korea), which is the specialized autonomic nervous system balance tester.

3 Result of the experiment

3.1 Variation of the amenity according to multi-sensory stimulation

The outcome of measuring asymmetry index and relative $M\alpha$ wave in EEG according to multi-sensory stimulation is as Fig. 1. The asymmetry index stands at 0.0074 in the multi-sensory stimulation of jasmine scent and fluctuation $a=1.106$ sound source compared to being exposed to multi-sensory stimulation, thereby being the closest to "0." Even relative $M\alpha$ wave stands at 1.9572[%], thereby being activated the most. In addition, Neuro-energy of relative $M\alpha$ wave was increased 3.05% more than before exposure. The result of ANOVA statistical verification on relative $M\alpha$ wave is as Table 1. The value of significance probability (P) stands at 0.016, thereby being able to be known to be statistically significant.

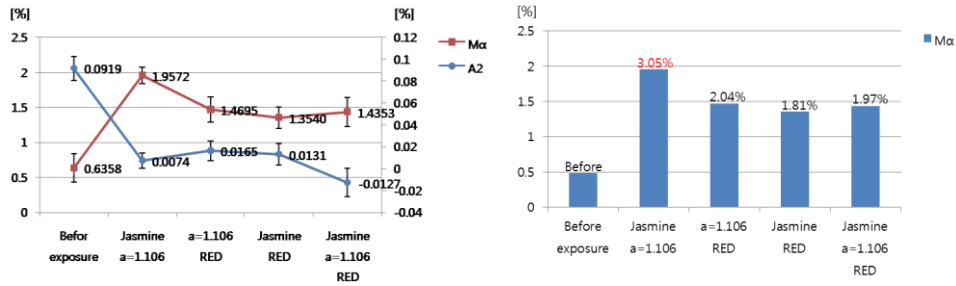


Figure 2 Variation of A_2 asymmetry and relative Ma wave due to multi-sensory stimulation

Table 1 Statistical analysis of relative Ma wave

	Sum of Squares	DF	Mean Square	F Value	Pr>F
Relative Ma	0.281	74	0.016	3.968	0.016**

3.2 Variation of the concentration according to multi-sensory stimulation

The result of measuring SEF50 and SMR/ θ in EEG according to multi-sensory stimulation is as Fig. 2. SEF50 was activated the most with 111.2016[%] in the multi-sensory stimulation of jasmine scent and fluctuation $a=1.106$ sound source compared to being exposed to multi-sensory stimulation. SMR/ θ was also activated the most with 6.4910[%]. In addition, Neuro-energy of SEF50 was increased 28.69% more than before exposure. The result of ANOVA statistical verification on SEF50 and SMR/ θ is as Table 2. The value of significance probability (P) stands at 0.062 and 0.021, respectively, thereby being able to be known to be statistically significant.

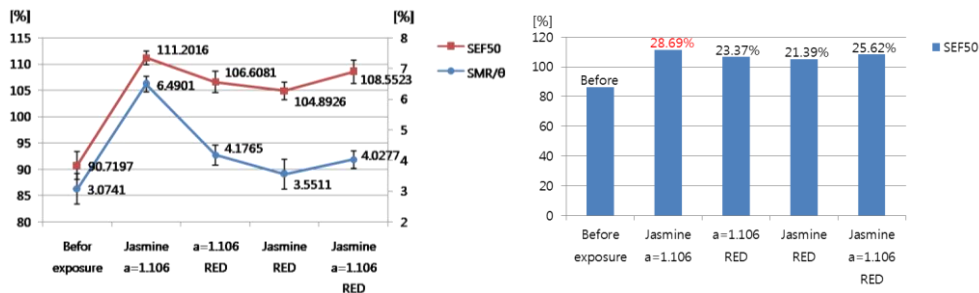


Figure 3 Variation of SEF50 and SMR/ θ wave due to multi-sensory stimulation

Table 2 Statistical analysis of SEF50 and SMR/θ

	Sum of Squares	DF	Mean Square	F Value	Pr>F
SEF50	1347.803	74	86.128	4.301	0.062**
SMR/θ	7.262	74	0.431	5.977	0.021*

3.4 Variation of the physical stability according to multi-sensory stimulation

The outcome of measuring Mean Heart rate, HRT, and Standard Deviation of all the normal RR intervals, SDNN according to multi-sensory stimulation is as Fig. 3. HRT lowers the most with 59.6[bpm] in the multi-sensory stimulation of jasmine scent and fluctuation a=1.106 sound source compared to being exposed to multi-sensory stimulation. SDNN stands at 56.9[ms] as well, thereby being able to be known to rise the most. In addition, Neuro-energy of SDNN was increased 58.5% more than before exposure.

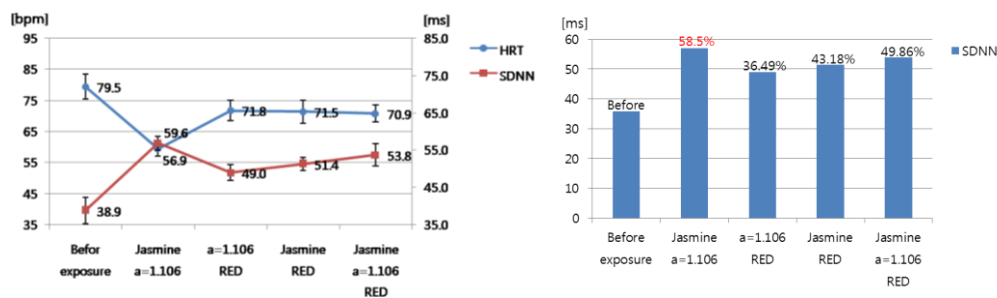


Figure 4 Variation of HRT and SDNN due to multi-sensory stimulation

4 Conclusion

As a result of the experiment, sensitivity, mind & body rest, and concentration rose the most in the multi-sensory stimulation of jasmine scent and fluctuation a=1.106 sound source. The body and the heart showed stably physical condition. Also, averagely 22.26% of neuro-energy could be known to grow when being exposed to multi-sensory stimulation compared to before being exposed to multi-sensory stimulation. However, given being performed a research and a consideration by using more various multi-sensory stimulation conditions hereafter in light of what the stimulus condition in auditory, vision, and olfactory sense is one thing each, the optimal multi-sensory stimulation condition is judged to be possibly found in consideration of an occupant's mental state along with the objective of space. Accordingly, in case of needing to inevitably maintain the indoor temperature at 28°C in summer and 18°C in winter according to the Energy Utilization Act, the multi-sensory stimulation space design is expected to be likely to be a plan available for reducing fossil fuel energy and enhancing neuro-energy.

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